important subject as the reality or unreality of heterogenesis, persons like Mr. Massee, who could speak authoritatively, should not think it necessary to make personal observations, and should be content to offer in reply to real and prolonged work only loose explanations which will not bear any serious examination.

A further instance of the same lack of care is afforded in the last sentence of Mr. Massee's letter. Referring evidently to my remark (NATURE, November 24, 1904, p. 77) as to the very different products that may be met with in the scum forming on an infusion made from unripe grasses as compared with that forming on an ordinary hay infusion, he says:—"As these fungi only develop on fading leaves it was not to be expected that they would appear in infusions of young grass." This sentence must have been penned without the writer having taken the trouble to look at p. 87 of my "Studies in Heterogenesis," to which reference was made when I directed attention to the differences in question. Had he done so he would have seen how little he had explained the differences noted on that and on the following page, and he would also have seen that the most striking difference recorded is the complete absence of Zooglœa masses (spoken of there as "areas") in the scum forming on infusions of unripe grasses. Of course if the Zooglœa masses are not there it is easy for me to understand the absence of the Fungus-germs which, as I maintain, are produced therefrom.

This point, as well as others in Mr. Massee's letter, shows the great importance of bearing in mind two wholly distinct aspects of my observations, corresponding with different stages in the processes described. We have to do (1) with the growth, the individualisation, and the processes of segmentation taking place in masses of Zooglœa. We have also to do (2) with the question of the ultimate destination, or the transformation, of the products of such segmentation. These are two parts of the subject which are to some extent distinct, and are well worthy of further separate consideration.[1]

In conclusion I would ask, Why do the bacteriologists not tell us what they know about Zooglœa—whether they are or are not aware of its developmental tendencies, and why it should undergo processes of minute segmentation, unless such processes are a result of an organising tendency destined to have some definite outcome? Why, again, should it or its segments so often tend to assume a brown colour, while it is still nothing but Zooglœa, either segmented or unsegmented? Again, why, if the brown Zooglœa does not yield the brown Fungus-germs, should there be this constant association of myriads of brown Fungus-germs (in the absence of hyphæ) in association with brown masses of Zooglœa? How can they explain, other than I have done, the actual organisation of a Zooglœa mass, and the stages by which the brown Fungus-germs seem to be formed therein? What process of "infection" in a filtered hay infusion contained in a closed pot could cause thousands of small Zooglœa masses to go simultaneously through similar processes of this kind—producing myriads of brown Fungus-germs—when not a single hypha is anywhere to be found, and when at first no Fungus-germs are to be met with outside the Zooglœa masses themselves? I trust the bacteriologists will vouchsafe to give us some information on these points, or, if they cannot reasonably explain them, that they may be induced to work at the subject, and satisfy themselves that something important can be learned concerning bacteria, even though it be outside their laboratories and by methods other than their own.

H. CHARLTON BASTIAN.

Compulsory Greek at Cambridge.

As a corrective to much vague discussion, perhaps the following record of facts may be of interest.

Entering the University of Cambridge in 1886, entirely ignorant of the Greek language, I was, of course, obliged to pass the "Little-go" in order to proceed to the natural sciences tripos. The Greek subjects prescribed were the Gospel of St. Mark, the Pluto of Aristophanes, and the usual grammar papers, and, in conjunction with a friend similarly circumstanced to myself, I set to work to "cram" these by as "scientific" methods as we could devise, in order to pass with as little waste of time as possible.

Purchasing a copy of Wordsworth's "Primer of Greek Grammar," we read the nouns, adjectives, and the active voice of *τυπτω*—no more, and then started on the prescribed books. These we translated by aid of a good lexicon, word by word—thus learning the parts of the irregular verbs, which form a favourite subject in the grammar papers. Having been once through the books by this method, we procured the translations, and read these through five or six times, in order to become so familiar with the subject-matter of the books that we could translate most passages easily at sight after making out the leading words in them.

The actual time expended by us in the preparation of Greek for the examination was carefully recorded, and amounted to $105\frac{1}{2}$ working hours, and we passed the examination in the second class, with, I believe, a considerable margin of safety even in Greek. I need hardly add that my present knowledge of the language is *nil*.

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December 28, 1904.

Polyhedral Soap-films.

THE fact that polyhedral wire frames can be used for the purpose of forming films across them is well known, but there are some features of this subject, which I have investigated, which may be of interest.

If a frame of wire representing the edges of one of the simpler polyhedra, such as a cube or octahedron, is dipped into soap solution, then on taking it out it will have films attached to its edges and meeting roughly at a point in the centre of the figure, forming a number of pyramids standing on the faces of the figure. If, however, a more complex figure, such as the rhombic dodecahedron or the eicosihedron, be taken, then the effect will be quite different; the film will then simply cover all the faces except the one which was drawn out of the solution first. The former thing will happen if the area of the $(n-1)$ faces is greater than that required to form the pyramids, while the latter will occur if the reverse is the case.

If, now, in the case of the cube, for instance, after the pyramids have been formed, a film be applied to one of the faces, then a certain amount of air becomes entirely enclosed by film, and the bubble so formed settles in the centre of the frame, forming roughly a cube suspended in the frame by twelve sheets of soap-film. On closer inspection, however, it will be seen that the faces of this cube are convex, thus showing that the air in it is compressed. By inserting a tube this cubical bubble can be inflated or reduced in size, all the time retaining its convexity, so that if thus left in communication with the air it will collapse of its own accord. A little consideration shows the reason for this, namely, that three films meeting one another cannot be in equilibrium unless their planes are inclined to one another at 120°, since the tensions in all three are equal. But since the dihedral angle of a tetrahedron, cube, or octahedron is less than 120°, therefore in these figures the internal polyhedral film must always have convex faces.

From this I expected to get an exact polyhedron with plane faces in the case of the rhombic dodecahedron, since its dihedral angles are all 120°. On trying this it was found to agree remarkably with my assumption, only, as may be gathered from what has gone before, it was not quite so simple to obtain the central bubble as in the former case. After the $(n-1)$ faces had been covered with film the figure was again immersed so as to displace about one-half the air contained in it, and while thus immersed it was turned round so as to cover the one open face with liquid. On withdrawing it there was seen the plane-faced rhombic dodecahedron. The same result can be obtained by applying a film to the nth face and then exhausting some of the enclosed air by means of a tube. By using a tube, as in the former cases, the bubble can be enlarged

[1] My further observations on this subject will be found in the February number of the *Annals and Magazine of Natural History*.

or reduced at will by blowing or suction, and it will retain its size constant when placed in open communication with the outer air by means of this tube. This is, of course, the only plane-faced polyhedron which can thus be formed, faces, edges and vertices being entirely made out of soap films. If, on the other hand, a figure has its dihedral angles greater than 120°, then the internal bubble will have concave faces, and will, if placed in communication with the outer air, increase in size until it coincides with the faces of the frame, and will then be kept in equilibrium by their rigidity. This I verified in the case of the eicosihedron.

There is one important law which must be mentioned. I found a certain irregularity in the behaviour of the films in the case of the octahedron and rhombic dodecahedron. This was due to the fact that two films cannot cross one another at right angles, a law which can be put to the test by placing two plane loops covered with film at right angles, when a small lanceolate film will be formed making two curved lines of intersection with the film on the loops, instead of allowing them to intersect in a single straight line. In the case of the rhombic dodecahedron this slightly modifies the form of the internal bubble, introducing a small edge and a little curvature at each of the acute vertices. This defect causes a serious convexity if the bubble is small, but in general we have double curvatures at the points in question, the remaining portion of each face being plain while the figure retains the form of a rhombic dodecahedron. W. F. WARTH.

Reversal of Charge from Electrical Induction Machines.

THE reversal of the poles of a Voss machine by giving some turns in the wrong direction, as observed in NATURE of January 5 (p. 221), is not an unknown phenomenon. It is described in my paper "Essai sur la Théorie des Machines électriques à influence" (Gauthier-Villars, Paris, 1898), p. 38, together with a much more trustworthy and simpler means—an improvement, in theory and in fact. This consists in discharging by hand, at the same time, both the inductors of the fixed disc. Then the reversal is invariably observed without stopping the machine.

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THE CONSTRUCTION OF SIMPLE ELECTROSCOPES FOR EXPERIMENTS ON RADIO-ACTIVITY.

THE electrical method, where it is applicable, is now by far the most sensitive method of detecting small quantities of matter; and the recent advances in physical science made by the method of measuring small leakages of electricity, especially in connection with the phenomena of radio-activity, have excited a very general interest in the experimental arrangements employed. The writer hopes that the following account of simple electroscopes for this kind of work will be found to be of a practical nature and of service to those who, though unfamiliar with many of the devices in general use in a physical laboratory, are nevertheless desirous of making quantitative experiments on radio-activity or some other subject where the electrical method is employed.

In general the final shape of the instrument will depend very much on the purpose for which it is required; in fact, it is one great advantage of the gold-leaf electroscope that it can usually be fixed up in any odd corner of the apparatus which happens to be convenient. There is, however, one part of the apparatus which is always the same in sensitive instruments, and that is the gold-leaf system itself. Before describing this it will perhaps make things clearer if we consider for a moment one or two points about the theory of the instrument.

What we observe usually is the rate of decrease of the deflection of a charged gold leaf from a vertical metal support to which it is attached. Now the deflection in question depends only on the shape and size of the leaf and of the metal support, and on the electrostatic potential of the system, so that the rate of collapse of the leaf measures the rate of decrease of the electrostatic potential. But what we wish to measure is the current or rate of alteration of electric charge, and this is equal to the rate of decrease of potential multiplied by the electrostatic capacity of the system. Thus for a given current the rate of movement of the gold leaves is greater the smaller the capacity of the system. For a sensitive instrument it is therefore absolutely necessary to have the parts which are metallically connected with the gold leaf as small as possible.

Cutting gold leaves is a process which requires a considerable amount of patience, especially from the beginner. The process I always adopt is to take a plate of glass and lay a sheet of smooth note paper on it. On this the gold leaf is spread out flat by blowing gently if necessary, and is cut by means of a razor. To do this, all except a narrow strip at the edge is covered with a second sheet of note paper, the straight edge of which is pressed down with the fingers so as to hold the gold leaf. A fine strip outside the edge of the paper is then cut off from the leaf by dragging the razor gently backwards parallel to itself and to the edge of the paper. It is not necessary to exert any great pressure during this operation, but a little practice will be necessary to get into the way of doing the saw-cut stroke at the proper speed. Mr. C. T. R. Wilson has succeeded in this way in cutting uniform strips one-tenth of a millimetre across, but for most purposes strips one millimetre wide are good enough. In working with gold leaf much trouble will be saved by working in a room which is free from draughts and disturbances generally.

For the metal support to which the gold leaf is attached it is convenient to use a piece of wire of about the same diameter as the thickness of the gold leaf. To fix the leaf on to the wire it is sufficient just to moisten the latter at the point of attachment with the tip of the tongue; on allowing the end of the gold leaf to come in contact with the very slightly moist wire it will be found to attach itself sufficiently firmly for all that is required of it. For obvious reasons the cutting and mounting of the gold leaf should be the very last operation in the construction of the electroscope.

In constructing an electroscope it is of the utmost importance to have trustworthy insulation. When the apparatus has not to be raised to a high temperature, and great mechanical strength is not required, sulphur is a long way better than anything else for this purpose. Generally speaking, it is better to have as small a quantity of insulating material as possible in order to diminish irregularities caused by the superficial charging up of the dielectric. Suppose we wish to insulate the wire carrying the gold leaf from another wire which supports it mechanically we should proceed as follows:—Take a porcelain crucible and gently heat a quantity of pure flowers of sulphur in it until it just melts and forms a clear yellow limpid liquid. It is important that it should not be heated so strongly as to become dark coloured and viscous, as this appears to diminish its subsequent insulating properties. The end of one of the wires is then dipped into the liquid sulphur, when a coating of sulphur forms on the wire. This is allowed to cool until it has solidified, and the operation is repeated a number of times until a bead of sulphur like that shown in Fig. 1 A has formed on the end. The end of the other wire is now heated gently in the flame and applied with a slight pressure to the point *a*, when it melts its way into the sulphur;